Filling Up With Hydrogen 2000

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Objectives

- Design and build fuel appliances based on new low-cost electrolyser technology.
- Demonstrate hydrogen vehicle re-fueling using fuel appliance systems.
- Obtain '3rd party operating experience feedback' in refueling applications.
- Establish precedents for development of codes and standards.
- Determine cost effectiveness of fuel supply pathway.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- B. Storage
- C. Hydrogen Refueling Infrastructure
- D. Maintenance and Training Facilities
- E. Codes and Standards
- H. Hydrogen from Renewable Sources

Approach

Prototype development involving building 8 different appliances: six Fleet Fuel Appliances and 2 Personal Fuel Appliances; each appliance project includes five phases:

- Design
- Build
- Test
- Customer evaluation
- Tear-down and post mortem

Accomplishments

- All six Fleet Fuel Appliance prototypes have been constructed, featuring different technical advances. All units have entered the customer evaluation phase. The Community Fuel Appliance (CFA) is now a commercial product offered at fixed scope and price.
- The Personal Fuel Appliance part of the program has been completed, and the final report for this part of the project has been submitted. The units continue to operate as demonstration prototypes.

Future Directions

- Complete installation of Mark I unit at SunLine Transit, 1000 Palms, California.
- Analyze performance of systems in the field; determine operating and manufacturing costs.
- Complete project by September 31, 2003. Report results and recommend improvements for next cycle of fuel appliance development.

Introduction

"Filling Up with Hydrogen 2000" is a prototyping development project intended to validate the Stuart Fuel Appliance Model for hydrogen vehicle fuel supply infrastructure. Stuart fuel appliances are purpose built on-site electrolytic hydrogen generators for refueling gaseous hydrogen vehicles. Using only electricity and water and having no emissions beyond oxygen, electrolytic fuel appliances can be readily deployed to create a highly distributed fuel supply network.

The objective of the Stuart/DOE project is to design, build and deploy a variety of fuel appliances. Two types of appliance are being built under this program: Fleet Fuel Appliances and Personal Fuel Appliances, both of which target the needs of nascent hydrogen vehicle commercialization. The Fleet Fuel Appliance targets buses, trucks and other centrally fueled fleet vehicles, where fuel production rates in excess of 400 SCFH are required. The Personal Fuel Appliance is geared towards consumer vehicles at the home or office and can be powered by the utilities found in the typical North American home. The production rate of these units is in the range of 50 SCFH. Both types of appliances are capable of delivering gaseous hydrogen at high pressure (up to 5000 psig) to the vehicle.

Approach

As presented in our Business Plan (Ref.1), the successful development and demonstration of fuel appliance technology will enable a cost effective pathway for building a hydrogen fuel supply infrastructure to support hydrogen vehicles in their early commercialization phase. The fuel appliance addresses the issue of fuel delivery by providing point-of-use fuel generation using existing energy utilities. Using the existing electricity grid, a full service infrastructure can be built up as a distributed network of small electricity-to-hydrogen fuel converters.

Key to meeting the market requirements is reducing the cost of electrolysis. Stuart's patented alkaline water electrolysis cell technology is designed to achieve the cost targets demanded by transportation fuels. The Compact Stuart Technology (CST) uses low-cost polymer and metal sheets, which are easily assembled in a stack. The CST electrolyser can be configured either as a single-stack or multi-stack electrolyser. The multi-stack electrolyser, having multiple cells in parallel, can run cell currents up to 30,000 amps and is suitable for large fueler applications. All the prototypes built under "Filling Up With Hydrogen 2000" use CST technology. The electrolyser packaged with the power system, compressor, purification and controls needed in a refueling application make up the fuel appliance.

"Filling Up With Hydrogen 2000" will provide an experience base with the cell stack technology for later commercialization and is a cost effective approach for equipment testing in that the user/ customer picks up operating costs for the benefit of the hydrogen produced. In addition to testing the cell technology, the prototype development plan provides public exposure to the fuel appliance concept, introducing customers to the idea of distributed on-site hydrogen production, and provides valuable precedents for the development of codes and standards and hydrogen project risk assessment. The operation of the bus fuel appliance (P3-1A) at SunLine Transit provides public access to the technology through SunLine. The low-pressure fueler (P3-1B LP) provides a demonstration of a system which can refuel metal hydride gas storage.

The high-pressure fueler (P3-1B HP) demonstrates the concept of a distributed "community fueler". The design of the bus fueler, P3-5, demonstrates the large format cell technology which could be used in large bus fleet fueling applications. The P4 prototypes are being used to test different configurations of the cell stack and integration with the compressor, including a pressurized stack configuration and integration with a wind turbine in a semi-stand-alone energy system. Testing of the personal fuel appliance (PFA P1 Model 25) by major automakers will provide the auto industry the opportunity to evaluate the concept of a small onsite hydrogen generator and a potential home-based fueling appliance.

Results

P3-1A: Bus Fuel Appliance, is now undergoing post-operation analysis. Over the three years at SunLine, it operated 3100 h and produced over 3.5 million SCF of hydrogen fuel. The appliance was used to fuel a variety of hydrogen and Hythane vehicles.

P3-1B (HP): Community Fuel Appliance, which produces up to 400 SCFH at 5000 psig, has operated for 5000 hours, producing 2 million SCF. The appliance has been used to test/certify hydrogen vehicle fuel tanks and fuel a fleet of Hythane vehicles. An identical version of this appliance has been delivered to the California Fuel Cell Partnership. (See Figure 1.)

P3-1B (LP): Community Fuel Appliance, which produces up to 400 SCFH at 200 psig, operated in-house for over 3000 h. It was refitted on a mobile deck and used for re-fueling a metal hydride - hydrogen fuel cell mining locomotive in a joint project with Fuel Cell Propulsion Institute (FCPI). (See Figure 2.)

P4-1A: Fuel appliance, capable of 400 SCFH at 6000 psig, incorporating higher-pressure stack, was tested in-house. Problems arose because of contamination on sensors used to control pressure in cell. Approach to CST cell pressurization has been abandoned with the company's acquisition of Vanderborre Hydrogen Systems and related cell stack technology.

P4-1B: Community Fuel Appliance, which can produce up to 900 SCFH, was used to test hydrogen motor generator set at Southwest Research Institute and is now being used to generate hydrogen from wind energy at a Palm Springs wind farm as part of a project with Southern California Air Quality Management District (SCAQMD). (See Figure 3.)

Mark 1: Commercial prototype of CFA-450 has been delivered to SunLine Transit 1000 Palms to replace P3-1A. This unit embodies all advancements learned from program. (See Figure 4.)

PFA Model 25: Personal fuel appliance has completed tour with Ford fuel cell vehicle. Final report has been issued.

Figure 1. P3-1B Fuel Appliance at Alameda County Transit, Richmond, CA

Figure 2. P3-1B Mobile Fuel Appliance for FCPI

Figure 3. P4-1B Fueler for SCAQMD Wind-Hydrogen Project

Conclusions

Fuel appliances can reliably meet the needs of hydrogen vehicle refueling, delivering gas up to 5000 psig. Prototyping has indicated further work is required to reduce equipment and installation costs and refine process automation.

Figure 4. Mark 1 Fueler for SunLine Transit

References

1. Stuart Energy USA, *Filling Up With Hydrogen*, 1998, under DOE Cooperative Agreement No. DE-97GO10221